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BAMBOO

CONSIDERED

AS A PAPER-MAKING MATERIAL.

WITH

REMARKS UPON ITS CULTIVATION AND TREATMENT.

SUPPLEMENTED BY

A CONSIDERATION OF THE PRESENT POSITION OF THE PAPER TRADE IN RELATION TO THE SUPPLY OF RAW MATERIAL.

THOMAS ROUTLEDGE.

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BAMBOO,

CONSIDERED AS A MATERIAL FOR PAPER.

REMARKS UPON ITS CULTIVATION AND TREATMENT.

Of all the fibre-yielding plants known to botanical science there is not one so well calculated to meet the pressing requirements of the Paper-trade as "Bamboo," both as régards facility and economy of production, as well as the quality of the "*Paper-Stock*" which can be manufactured therefrom: grown under favourable conditions of climate and soil, there is no plant which will give so heavy a crop of available fibre to the acre, no plant which requires so little care for its cultivation and continuous production.

The rapidity of the growth of "Bamboo" is unequalled. At Gehzireh, the gardens of the Khedive of Egypt at Cairo, it has been known to grow nine inches in a single night. At Syon House, the Duke of Northumberland's, stems of "*Bambusa Gigantea*" have attained the height of 60 feet in 12 weeks; and I have made "*Paper-Stock*" from a stem of "*Bambusa Vulgaris*," sent me by Dr. Hooker, from the Royal Botanical Gardens at Kew, which, as measured by the gardener in the Palm-house, grew at the rate of three feet in a single week; at Chatsworth, the Duke of

Devonshire's, this same variety (the "*Bambusa Vulgaris*") has attained the height of 40 feet in 40 days.

Throughout the East Indies the "Bamboo" flourishes, forming indeed in many districts impenetrable jungles. It grows abundantly also in the West Indies, in Central and South America, the Brazils, in Africa and Asia; in China especially, and in Japan, the plant is indigenous, and the natives cultivate it carefully, employing it for almost every article of convenience and luxury; in fact, wherever heat and moisture exist, some species of the "Bamboo" will be found, or may be readily cultivated.

Attempts have from time to time been made in England, and elsewhere, to obtain from the "BAMBOO" "*Half-stuff*" or "*Pulp*," suitable for the manufacture of paper, and paper indeed has been made therefrom, but hitherto these attempts have neither industrially nor commercially attained successful results, and for the following reasons.

Hitherto the "BAMBOO" has been collected and treated in a condition more or less of maturity, or without regard to its age; and when the plant has attained its full growth the woody fibre is extremely dense and indurated; when old, indeed, the exterior portion of the stem of many varieties of the plant becomes so hard and silicious that it will, like flint, strike fire with steel.

Owing to the presence of this large quantity of silica, and the extreme hardness of the stem when

developed and matured, it has been found by all those who have hitherto experimentally treated "BAMBOO" that the only possible means of converting it into *Pulp* for Paper-making, has been to subject it to long-continued boiling, or digesting, in very strong solutions of caustic alkali, at an elevated temperature—in other words, at or under a pressure of ten to eleven atmospheres (150 to 160 lb. pressure per square inch) —by which means a *Pulp* has certainly been produced, but at a great cost, and the danger and practical difficulties of working under such high pressure, have deterred further progress in this direction.

I have found that when the stems of "Bamboo," are cut down at an early stage of their growth, when the plant is full of sap, and before the cellulose or cellular tissue, and the lignine have become indurated, and silica deposited; while, in fact, so to speak, the plant may be termed a succulent vegetable, and before it has become converted into wood, that a very mild system of treatment in successive weak alkaline baths, at atmospheric pressure only, suffices to decompose and render soluble the mucilaginous and other extractive compounds combined naturally with the fibrous tissue of the plant, so that they may be readily eliminated, or separated therefrom, by subsequent washing, leaving the residuary fibres pure and free.

A comparative illustration of the transitional stage of growth above referred to, showing the conversion of succulent vegetable fibrous tissue, into harsh woody

fibre, may be remarked with "Asparagus," the young and green stems of which, are used as a delicacy for the table, a few weeks further growth converting them into hard woody fibre, which no amount of boiling would, or could, render palatable; the "Asparagus," indeed, has its parallel in the "*Bambusa Edulis*," a variety of "BAMBOO," the young stems of which are eaten and considered very nourishing.

The "BAMBOO," being an *endogenous* plant, (that is to say, growing from inside) composed mainly of fibrous tissue, combined with the ordinary sappy and other extractive matter common to all vegetable growth, the stems do not require the elaborate preparatory manipulation which is necessary to separate the fibrous, from the extraneous and woody matter, which in *exogenous* plants (i. e. growing from, or on the outside) must be removed, as it is only the true fibre which is useable for Textile Manufactures.

Such plants known to commerce as "FLAX," "HEMP," "JUTE," "RHEA," &c. &c., after having become mature, and being dried, have to undergo a process of retting, or steeping, followed by scutching and heckling, in order to separate the ultimate fibres from the woody stem and bark to which, while in their normal condition, they are attached.

The cost therefore, of producing merchantable fibre from this class of plants is very considerable, and the produce or yield of fibre, to the plant cultivated, very small, that of "FLAX" being computed at from 5 to

6 cwt., "HEMP" 7 cwt., and "JUTE" 5 to 6 cwt. per acre, "COTTON" being much less; "BAMBOO," as I will presently show, producing tons as compared with cwts. of the foregoing, and, be it noted, with far less cost for cultivation, and the subsequent preparation of the fibre.

The stems of the "BAMBOO," cut young, as I propose to use them, contain from 60 to 75 per cent. of moisture; it will be obvious, therefore, that to ensure a regular and continuous supply, under economical conditions, to a central factory for the manufacture of "*Paper-Stock*," plantations would have to be formed contiguous thereto, as practised with "SUGAR CANE," or in a similar manner to Osier beds, in England.

I have mentioned the latter, as in order to stimulate a rapid, aqueous, and sappy growth, as also to provide for the dry seasons common to hot countries, a system of irrigation would be necessary, such a system indeed being at present practised with the SUGAR CANE, in Egypt, Spain, and elsewhere.

With plantations of "Sugar Cane," to which plant the "BAMBOO" somewhat assimilates in character and growth, it is necessary, in order to ripen the canes and develop saccharine, to allow free ventilation to the growing plant, and thus the ground is not fully occupied; this would not be the case with "BAMBOO," which should be planted and grown closely together to favour the stems shooting upwards, as practised

with "HEMP" and "FLAX," where fine staple of fibre is desired.

By following such a system, the stools or roots once established, a systematical and regular cropping, or cutting, would ensue, the stems being all cut down simultaneously, by sections or beds, in regular succession, numerous croppings annually would thus be obtained, and when necessary, fresh beds would be formed, the older growth being available for fuel for the manufactory.

The Sugar Cane from the time of planting, to cutting, takes from nine to twelve months to grow and mature; but even thus grown, the produce of canes (ready dressed for the mill) generally ranges from 30 to 35 tons to the acre, it sometimes exceeds 40 tons; allowing several crops or cuttings annually for the "BAMBOO," it may fairly be assumed that at least this latter quantity would be obtained per acre.

Allowing 208 feet square to represent one acre; divided into twelve beds, each 96 × 26 feet, with twelve paths 96′ × 8′ 8″ wide, and one intersecting road 208 × 16 feet wide, leaves a space for planting equal to 2496 feet, or 29,952 feet in the twelve beds; allowing the stems to be 2 feet apart, and say only 12 feet high, we have 7488 stems, which at 12 lb. each = 40 tons per acre.

The stem of the "*Bambusa Vulgaris*" before mentioned, grown in the Palm-house at Kew, was of an average size, 10 to 11 inches circumference, and weighed green 1½ lb. per foot run; and although

no doubt by denser growth, induced by frequent cropping, the stems even of the larger varieties of "BAMBOO" would decrease in size, still an equal tonnage to the acre would be produced, with longer joints or internodes, and a finer staple of fibre.

The stems of the "BAMBOO" (*taken as dry*) treated by my process, will yield 60 per cent. of unbleached *Fibrous* "*Paper-Stock*," baled up in merchantable condition; assuming therefore an annual cropping of 40 tons, green stems, which will lose 75 per cent. moisture in drying, we have 10 tons dry stems per acre; these at 60 per cent. yield, will give 6 tons per acre of "*Paper-Stock*," an enormous product as compared with any other fibrous material with which I am acquainted.

Allowing the plantation to be credited at the rate of 5*s*. per ton, for the green stems, delivered to the central factory, and 40 tons to be produced per acre, we have the sum of 10*l*. per acre to cover all charges; once, however, the plantation formed, but little cost in the way of cultivation need be incurred. The main outlay would be for rent, irrigation, and cutting, and carrying to the manufactory.

I may here remark that I propose where possible, to return to the *Plantation*, mixed with the water employed for irrigation, the mucilaginous and other extractive constituents, or matters, (amounting to 40 per cent) abstracted from the stems during the process of manufacturing the "*Paper-Stock*," as Manure, thus maintaining fertilization to the growing plant.

Details of my System of Treating "Bamboo" for the Manufacture of Fibrous "*Paper-Stock.*"

An essential point in my system for treating "Bamboo" to produce therefrom fibrous "*Paper-Stock,*" consists in operating upon the stems of the plant when young, and preferably when fresh, as, and when, cut and collected.

Brought therefore to a central factory in this condition, the stems are passed through heavy crushing rolls, in order to split and flatten them, and at the same time crush, or smash, the knots, or nodes. The stems thus flattened, are then passed through a second series of rolls, which are channelled, or grooved, in order further to split, or partially divide them longitudinally into strips, or ribbons; these being cut transversely, into convenient lengths by a guillotine knife or shears, are delivered by a carrier, or automatic feeder, direct to the boiling pans, or elsewhere, as desired.

As the stems when fresh and green, contain from 60 to 75 per cent. of sappy and mucilaginous matter, much of this is expressed by the crushing, while at the same time the fibrous mass, being partially disintegrated, is thus more readily acted upon in the succeeding processes.

If desired, the crushed stems may be dried and stored; such drying, however, must be very carefully

conducted and watched to avoid destructive fermentation.

I have in the preceding "Remarks" referred to "FLAX," "HEMP," "JUTE," and similar FIBRES known to commerce, such fibres being imported into this country in their prepared condition, suitable for Textile purposes. They have, in fact, passed through a process of semi-manufacture, such process, as I have explained, being required to separate the ultimate fibres from the interior woody stem to which when growing they are attached; and it is obvious that it would not be (economically) possible to import any of these fibrous plants as grown or produced, owing to their enormous bulk in that condition.

Now although the stems of the "BAMBOO," after cutting and crushing, may, as I have shown, be dried (and will when dried give a yield of 60 per cent. of fibre), still their bulk and extreme lightness would preclude importing them to this country in their *raw* condition, not merely from their heavy cost for carriage, but from their liability to damage from fermentation. For these economical considerations, therefore, I propose to reduce the "BAMBOO" into "*Fibrous-Stock*" where grown or produced.

It may be well, before entering into details of the process, briefly to explain the ordinary system employed for preparing fibres, or fibrous materials, as also rags, for Paper-making. This consists in sorting, cutting, cleaning, and, if need be, roughly opening them, followed by boiling in alkaline leys, after which

they are well washed until cleansed from impurities in what is technically termed the rag or breaker engine, during which operation they are disintegrated or reduced into "*Half-stuff*," or *semi-pulp*, this being subsequently bleached and converted into pulp and paper.

As the object of my process is to produce a fibrous or tow-like *Stock*, retaining as far as possible the normal or natural condition of the fibre, and not "*Half-stuff*" or "*Pulp*," my system of treatment differs materially from the foregoing, more especially in the boiling and washing processes.

Both of these processes I conduct in a battery, or series of vessels (16, 20, or more in number), such vessels being connected together by pipes, or channels, furnished with valves, or cocks, so that communication between the individual vessels may be maintained, disconnected, and regulated as desired, in such manner that the vessels, being methodically charged in succession with the material to be operated upon, the heated leys (composed of caustic alkali) can be progressively conducted from vessel to vessel of the series, passing over and through the material placed therein.

The leys are thus used again and again, (each successive change, or charge of ley, carrying forward the extractive matters it has dissolved from the fibre with which it has been in contact) until exhausted or neutralized, (when they are discharged), fresh leys being methodically, and successively, supplied, until by degrees, the extractive matters combined with

the fibre or fibrous material have been rendered sufficiently soluble, when hot water for washing, or rinsing, is in the same continuous manner run successively from vessel to vessel, over, and through, the material contained therein, until the extractive matters rendered soluble by the previous alkaline baths have been carried forward and discharged, leaving the residuary fibre sufficiently cleansed.

By this system of boiling in continuity, until all the effective alkali in the leys is exhausted or neutralized, I realize an economy of from 30 per cent. to 40 per cent. of soda over the ordinary process of boiling, and by the subsequent washing, or rinsing, in the same continuous manner, without removing the material from the vessels, the normal structure of the fibre is in a great measure retained, waste is minimized, and thus, while being thoroughly cleansed and freed from extraneous matter, the strength and staple of the fibre are preserved; a considerable saving of fuel results from the heated liquors being used again and again, less steam being required, as also less water, while at the same time economy of both labour and power is effected over the ordinary system.

Assuming the boiling and succeeding washing processes to be concluded, and the material ("BAMBOO") in one of the vessels of the series in its regular succession, to be found sufficiently treated and cleansed, a final cooling water is run on and through the fibre, which is then drained, and the contents of the vessel (disconnected for the time being from the series)

emptied into a waggon running on a railway, by which it is conducted to a press or otherwise to abstract all the remaining moisture possible.

The dry, or semi-dry fibre, is then submitted to the action of a willow, or devil, by means of which it is opened or teazed out, and converted readily into a tow-like condition, when it is dried by a current of heated air, induced by a fan-blast, and finally baled up for storage or transport, in a similar manner to COTTON or JUTE.

In this condition of "*Paper-Stock*," it may be kept an indefinite length of time without injury, and when received by the Paper-manufacturer requires merely soaking down and bleaching, to fit it for making into paper, either by itself, or used as a blend with other materials, as desired.

The minuter details of my process for treating raw fibres, or fibrous material, for the manufacture therefrom of *Fibrous* "*Paper-Stock*," are fully described in my several Patents, the only variation so far as relates to "Bamboo" being the preliminary preparation of the young stems, the other portions of the process being substantially the same as in daily operation at the Ford Works, Sunderland, for the treatment of "Esparto," and other "*raw fibres*."

I have only now further to remark that the "Plant" required to manufacture "*Paper-Stock*" from "Bamboo" on an economical and practical working scale, would consist of a battery of boiling pans, with the other necessary adjuncts and machinery,

steam engines and steam boilers, such "Plant" being on a scale adequate to the manufacture of 100 tons "Bamboo" weekly, producing therefrom say 60 tons merchantable "*Paper-Stock.*"

As the above scale of operations, viz. the Manufacture of 100 tons ("BAMBOO") weekly into "*Paper-Stock,*" may appear somewhat large, it is necessary I should explain that owing to the nature of the Process, the desired effect being produced by the reiterated and continuous action of repeated *weak* Alkaline Baths or Leys, in a Series of Vessels, such an operation involves the treatment of a large quantity of "*Raw Material,*" at one time, and cannot either conveniently or economically be conducted upon a much smaller scale.

The cost of the "Plant" and Machinery required for such a Factory would amount to about , packed ready for shipment in England, to which would have to be added the carriage and cost of erection, with the necessary buildings, which, however, would be of a very simple and inexpensive character.

I do not feel myself competent to determine what quantity of Land would be required for a plantation to supply such a factory, which would absorb 100 tons dry, say 400 tons green, "Bamboo" stems weekly, but assuming 40 tons produce to the acre, with only once annual cropping, 500 acres should be ample. This calculation doubtless would be influenced by the varying conditions of climate and soil, as also by the variety of "Bamboo" cultivated.

It may be expected that I should in these "RE-

MARKS" include some reference to the "*Variety*" of "BAMBOO" which could be most economically and profitably cultivated for the supply of such a Factory, on the scale I propose.

In respect to this portion of my subject I experience some difficulty, inasmuch as the *Varieties* of "Bamboo" are so numerous, and so widely distributed.

A Monograph by Colonel (now General) Munro, C.B., published in the 'Transactions of the Linnean Society,' affords the most elaborate and comprehensive description of the "Bamboo:" in this paper upwards of 170 species are described.

The "*Bambusa Vulgaris*," as its name indeed denotes, appears to be the most generally distributed, as it is found in both Hemispheres, General Munro being in considerable doubt as to which it is a native of.

I quote from his Monograph: "I have seen it "collected by Wallich, in Silhet, by Hooker, in Chitta-"gong (both North-east India), from Ceylon wild, in "the Mauritius cultivated abundantly, in the West "Indies naturalized, and cultivated in several parts of "South America, this is the only thoroughly cosmo-"politan species."

Bambusa "*Gigantea*," growing to the height of 120 feet and from 25 to 30 inches circumference; B. "*Edulis*," or edible Bamboo; B. "*Arundinaceæ*;" B. "*Balcooa*;" B. "*Brandisii*," &c., all varying in growth to from 60 to 70, to 120 feet high, abound throughout India, and all our Asiatic Dependencies. In the West

Indies also, where not now indigenous, doubtless any variety selected could readily be introduced and cultivated.

To conclude, it would appear that with the "*Raw Material*" "Bamboo," we have under our control "an embarrassment of riches," and I have only further to add that I know of no other that can at all approach it in economy of production, and I believe very few if any in the quality of the "*Stock*" produced therefrom suitable for Paper-making purposes.

BAMBOO,

CONSIDERED AS A PAPER-MAKING MATERIAL.

THE PRESENT POSITION OF THE PAPER TRADE IN RELATION TO THE SUPPLY OF RAW MATERIAL.

"THE deficient supply of, and the increasing price for, "the materials for making paper and the prospect of "a still greater consumption has for some time excited "the attention of manufacturers and the public."

The above REMARKS prefacing a MEMORANDUM drawn up by Dr. Forbes Royle, reporting for "THE COMMISSIONERS FOR THE AFFAIRS OF INDIA," at the desire of "THE LORDS OF HER MAJESTY'S TREASURY," and of "THE LORDS OF THE COMMITTEE OF THE PRIVY COUNCIL FOR TRADE," in 1854, and subsequently published in his valuable work, "THE FIBROUS PLANTS OF INDIA," in 1855—twenty years ago—truly represent the position of the Paper-Trade at the present time.

The extension of education and literature, the necessity for cheap newspapers and serial publications, the increased demand for paper for writing, as also for manufacturing and commercial purposes generally, have greatly stimulated consumption, and

it is believed that since the abolition of the Excise duty in 1861, the annual production of paper has more than doubled.

Previous to 1861, raw fibrous material, with the exception perhaps of Straw, was but little used in paper-making, the waste of cotton, flax, hemp, and jute mills, having undergone a process of semi-manufacture, being comprised under the generic term of—Rags.

The American war, immediately following the repeal of the paper duty, threatening a cotton famine, the Paper-makers gladly availed themselves of a new material, "Esparto," which I had for some time previously been ineffectually endeavouring to introduce, and adopting my process for its treatment, this material entered speedily into consumption, and has tended more than anything else to promote the development of the Paper-trade by enabling the manufacturers to keep pace with the rapidly increasing demand.

The importations of "ESPARTO," which did not amount to 1000 tons in the year 1860 (indeed up to that date I was the only manufacturer using it*), rose to upwards of 50,000 tons in the year 1865, and by 1871—ten years only from its introduction—the annual imports had attained the large total of 140,000 tons.

* The Journal of the Society of Arts, 28th Nov., 1856, was printed on paper made from Esparto, at Eynsham Mills, near Oxford, then in my occupation.

"ESPARTO" being a wild grass (or, botanically speaking, a sedge) growing on waste lands, in Spain and Africa, owing to the greed of the native collectors —who, while gathering the plant, pluck it up recklessly, roots and all—is being gradually but surely exterminated.

The complete exhaustion of the plant is proceeding very rapidly in Spain; and as it is estimated by the best informed authorities that it will take, even with the greatest care and under the most favourable conditions, at least fifteen years to reproduce it from seed (a system not very likely to be pursued in that country,) at no very remote period this valuable paper-making material appears doomed to extinction.

During the last few years a large and increasing supply of "ESPARTO," or as it is there called "*Alfa*," has been received from Africa; and although the quality of African Esparto is not valued by the paper-trade as high as the Spanish, still it meets with a ready sale, being used to mix with, or in substitution of the latter.

As much as 60,000 tons were imported last year (1874) from Algeria, and great inducements by concessions and otherwise, are offered by the French Government to induce railway communication with the interior districts of that country, where the plant is said to abound on some of the mountainous plateaux, and thus for some little time the market may be supplied, but the difficulty of procuring labour, and the cost of railway carriage for such long distances, will

add considerably to the present charges of transit to this country.

Within the last two or three years, the Belgian and American Paper-makers have commenced using "Esparto," and so latterly have the French, and as our main sources of supply will now be Algeria, (a French colony,) any material reduction in prices can hardly be looked for.

"ESPARTO," like other commercial products, is amenable to the law of supply and demand; and thus, as the demand is, and is likely to continue in excess of the supply, its cost has enormously increased, the price it now commands in the market being nearly double that, at which I sold many thousand tons during the early years of its introduction.

The Paper-manufacturers are thus again experiencing the same difficulty recognized by THE LORDS OF THE TREASURY, and by THE BOARD OF TRADE in 1854, and which more recently was considered of sufficient importance to induce the appointment of a SELECT COMMITTEE ordered by THE HOUSE OF COMMONS in 1861:

"To inquire into the DUTIES or PROHIBITIONS in "FOREIGN COUNTRIES on the EXPORT OF RAGS used in "the MANUFACTURE OF PAPER in the UNITED KING-"DOM, and their effect upon that MANUFACTURE."

The COMMITTEE REPORTED: "That the production "of paper in this country is in excess of the supply of "the material of which it is made, and the paper "manufacture is in consequence dependent for a large "portion of its supplies on foreign Rags, amounting

"to about 15,000 tons per annum, which is by "estimation a fifth of the whole quantity of Rags used "for the manufacture of white paper in this country, "on nearly the whole of which heavy export duties "are paid."

Another paragraph of the COMMITTEE'S "REPORT" states: "That the Committee have directed their "especial attention to inquiring as to the possibility of "applying any *New Fibre* as a substitute for the refuse "material now in use for Paper-making purposes, and "find that great efforts have been made to discover "some material of this nature, but as yet with little "success; and although they see no reason to doubt "that Straw and other fibrous substances may form a "supplementary part of the material for paper-making, "the great comparative expense of chemically reduc-"ing these *Raw Fibres* presents difficulties to their "becoming a substitute for the refuse material now "used."

Since the above "REPORT" was published, the position of the Trade has materially altered. The export duties in some countries have been abolished, in others reduced; Rag material has increased in quantity and diminished in price; "the difficulties of chemically reducing *Raw Fibres*" no longer exist; and the "15,000 *tons* of Rags" estimated by the "COMMITTEE" as the requirements of the Trade have been more than "substituted" by the 150,000 *tons of* "ESPARTO" *and other Raw material*, now annually imported, while the development of the chemical trade keeping pace with

the introduction of "RAW FIBRES" has materially facilitated their employment.

Caustic soda, but little known in 1861, is now extensively manufactured, and Weldon's new process has greatly increased the power of production and diminished the cost of manufacturing bleaching powder; thus "the comparative expense of chemically reducing *Raw Fibres*" is no longer an obstacle to progress.

The manufacturer of the present day will, in fact, undertake to make paper from any raw fibre, or fibrous substance that may be submitted to him.

He has, however, several questions to consider before he will commit himself to purchase or contract for any new fibrous material, these being: its cost, not merely as a raw material, but in the details of manufacture, and the quality of the paper that can economically be made from such fibre, either alone, or introducing it as a blend with the material he at present employs; then, assuming these points satisfactorily determined, he would desire to know the quantity of such material annually available, with some guarantee for continuous and reliable supply at a price not liable to erratic fluctuations.

The value of "ESPARTO" as a Paper-making material having been recognized, and its employment almost universally adopted in the Trade, naturally led to various attempts to introduce other "*new material*," which hitherto, however, have met with only partial success: the "DWARF PALM," *Chamærops humilis*, and "DISS,"

as well as some other materials from North Africa, have been tried and abandoned as unsuitable: "JUTE" also has latterly attracted considerable attention; "Butts" or "Cuttings," as they are termed, the refuse from the preparation of the long clean fibre now so largely used as a Textile, have entered extensively into consumption, being imported from India specially for paper-makers' use, packed in hydraulic-pressed bales; but this fibre is difficult and costly to bleach perfectly, and is only employed for the lower class of "News" and "Common printing," or unbleached, for "Brown" and "Wrapping" papers; but as it has long been familiar to the trade in the form of Waste, Gunny-bagging, and Rope, it can hardly be termed a "*New Material.*"

Two or three other excellent fibrous materials may be mentioned, small parcels of which are occasionally to be met with, that are, or more correctly speaking would be, much prized by Paper-manufacturers if obtainable at reasonable rates, such as "ADANSONIA BARK," "NEW ZEALAND FLAX," "MANILLA HEMP," "SUNN," and other INDIAN, HEMP-LIKE FIBRES, all of which will bleach well and make paper of superior quality; but unfortunately the quantity available is so small, and the supply so irregular and uncertain, that they can hardly be relied upon as "*Raw Material.*"

"WOOD," both chemically and mechanically prepared, has been, and indeed is now, used to a very considerable extent; but the latter, produced by grinding down "billets" from the tree as cut down, on a grindstone to a pulp, with water, or without water, to the

condition of flour, contains but little fibre, and that fibre with very little "felting" property (an essential for a good sheet of paper); thus it can only be used as a "filler-up" for "cheap News" and common papers, like "clay" (facetiously called in the trade Devonshire linen), or any other adulterant which the necessities of the Paper-maker, to meet the market, (*or in other words deficient supply of good and cheap suitable material*) compel him to use.

"WOOD," chemically prepared, is costly in production, as it is only possible to reduce it into *Pulp*, by boiling under very high pressure, with strong caustic alkali; several mills established both in England and Scotland, to carry out this manufacture, have abandoned it, and such *Pulp* as is now used in the Trade is derived exclusively from the countries where the wood is grown. The *Pulp* thus produced, although somewhat hard and harsh, if the wood is carefully selected, and properly prepared, will, blended with other material, produce a fair quality of paper.

The use of "STRAW," from the "*Cereals*," WHEAT, OATS, and RYE, has of late years greatly extended, both in this country and throughout the continent of Europe, as well as in the United States of America, either alone or as an admixture with rags and other material, for all classes of paper, as these countries equally with England suffer from a deficient supply of *Raw Material*; but in England, owing to the increased consumption for agricultural and feeding purposes, and influenced also by the scarcity and high prices lately ruling for "ESPARTO" in many districts, "STRAW"

has become very difficult to obtain, and considerable quantities have in consequence been imported from Holland and Belgium, both raw, and as bleached *Pulp*.

I may here mention two other fibrous substances, which have from time to time attracted considerable attention, viz. "MAIZE LEAVES" and "RICE STRAW," both of them *raw materials*, from which a fair quality of paper is produced in the countries where these plants are cultivated; but, as in their natural condition after being harvested they are far too bulky to permit of transport to this country, they would have to be reduced to a portable form where they grow, and even then, owing to the small yield of "*true fibre*," their economical conversion is somewhat doubtful, unless under favourable conditions.

The daily increasing demand for PAPER being recognized, and the impending if not immediate scarcity of *Raw Material* available for its manufacture, up to the present time, having been shown, to what quarter must the Trade look for an extended supply?

This it must be admitted has become an important question for consideration, it being evident that unless some "*New Material*" suitable for the purpose is speedily introduced, the "PAPER TRADE," one of the most important in the UNITED KINGDOM, will be seriously crippled; meanwhile of necessity high prices are maintained, and as a natural consequence the consumer suffers.

FIBRE-PRODUCING PLANTS—SOURCES OF SUPPLY.

The high value of land precludes the cultivation of any fibrous material exclusively for paper-making in England, even if this climate was suitable for its growth; with the exception indeed of "FLAX" and "HEMP," it would appear that northern latitudes are not favourable for the production of fibre-producing plants, and therefore it is to warm or *tropical countries* alone any reliable supply of "NEW MATERIAL" can be looked for.

In the *East*, and *West Indies*, in her *Colonies* and *Dependencies*, England possesses an inexhaustible supply of fibre-producing plants; in India especially, almost every plant abounds more or less in fibre.

In China and Japan, as also in India, from the earliest times, paper has been made exclusively from *raw indigenous virgin fibres*, and the paper produced in these countries is in consequence generally extremely strong and tough, and although unbleached, and not made in a fashion adapted to European requirements, affords ample and conclusive evidence of the valuable supply of material at our disposal.

VEGETABLE FIBROUS, or FIBRE-PRODUCING PLANTS, are divided by BOTANISTS into two distinct CLASSES or DIVISIONS: ENDOGENS, or inside growers; EXOGENS, or outside growers.

From the former are obtained the fibres known as "MANILLA HEMP" or "ABACA" (from the *Musa textilis* or *Plantain*), the "ALOE," "AGAVÉ" (or "*Pita*

Fibre"), the "YUCCA," "BROMELIA PENGUIN," "SISAL HEMP" (or *Hannequin*); "PINA FIBRE" from the "PINE APPLE" (*Ananassa sativa*), "MAROOL or MOORVA" (*Sanseveira Zeylanica*), "NEW ZEALAND FLAX" (*Phormium tenax*), &c.; "MAIZE" (or *Indian Corn*), "RICE," and other "CEREAL STRAWS," "ESPARTO," "DISS" and other "Sedges," various "Reeds," and "Grasses," the latter including "BAMBOO," "SUGAR CANE," are also comprised in this Class.

The FIBRES, or FIBROUS TISSUE enveloping the *Stems* of *Herbaceous Plants*, known as "HEMP," "FLAX," "JUTE," "HIBISCUS," (*Gombo* or *Okhro*), "RHEA," or "CHINA-GRASS" (*Urtica nivea*), "SUNN HEMP" (*Crotolaria juncea*), &c., as also the LACE BARKS (so called), such as the "ADANSONIA DIGITATIS" (from the *Boabab* tree), the "NEPAL PAPER PLANT" (*Daphne cannabina*), the "PAPER MULBERRY" (*Brussonetia papyrifera*), &c., constitute the latter Class.

I have confined myself to recapitulating *a few only* of the *fibres* in either class, best known to commerce; this list, indeed, might be extended almost indefinitely, as may be seen by reference to the work before alluded to, 'The Fibrous Plants of India,' by Dr. Forbes Royle, as also to the elaborate Paper on the same subject, read at the meeting of the Society of Arts, May 9, 1860, by Dr. J. Forbes Watson, Reporter on the Products of India, Dr. Royle's able successor.

With some few exceptions (notably "Esparto" and some of the Cereal straws and grasses), the resulting

or ultimate fibres from vegetable fibrous plants, before they can be utilized either for Textile purposes, or for the manufacture of Paper, must be freed from the extraneous substances with which during their growth they are more or less combined.

In the case of *Endogens*, the fibres are imbedded or enveloped in succulent, fleshy, or pulpy stems, or leaves; and in the case of *Exogens*, the fibre is combined with, and attaching to, wood, or woody matter, such extraneous substances or matters constituting, more or less, a considerable portion both of the weight and bulk of the plant even when matured.

Treatment of Fibre-producing Plants.

From all, or nearly all, *Endogenous* plants the fibres are extracted by hand labour, no machinery having been hitherto invented by which this operation can be performed in an economical and satisfactory manner.

The fleshy stems, or leaves, of this class of plants are crushed and beaten, macerated in water, scraped and roughly combed, to separate the fibrous from the vascular, or pulpy portion of the plant; sometimes the plants are buried in wet sand, or mud, leaving them to soak, or rot, for many days, then beaten on a stone, scraped, and combed; but by this system the fibres generally lose colour and strength. The yield of fibre from this class of *Endogens* ranges from 6 to 12 per cent., and it is only where native labour is exceedingly cheap and abundant that such a laborious and tedious process could be carried on.

The majority of the fibres from *Exogenous* plants

are also, in somewhat a similar manner obtained solely by manual labour; the herbaceous, or woody stems of such plants, being first steeped, or retted, to induce partial fermentation, and facilitate the separation of the corticular fibres, from the woody stem.

When produced in Europe, Flax and Hemp form an exception, being generally dried before steeping, which process is also more systematically and regularly conducted, and the subsequent separation of the ultimate fibres effected by breaking, scutching, and heckling; these operations being as far as possible carried out mechanically.

When the cost of cultivation, of carriage, freight to this country, charges and merchants' profit, are added to the outlay involved in producing clean fibres by the laborious and tedious processes described, even with the exceedingly cheap labour of *tropical countries*, it will readily be understood that they cannot be sold at a cheap rate.

When the above outlay has been incurred, and clean merchantable fibre results, such fibre will generally secure a high price in the market for Spinning, Roping, and other Textile purposes, far beyond the Paper-maker's limits, who therefore can only avail himself of damaged parcels, or such as, being of low or inferior quality, have been rejected by the "Spinner," and, even then, has to come into competition with the maker of low-class goods, the common "sacking and mat-maker," as any fibre of fair strength, long enough to spin into a coarse yarn, commands good value in the market.

It will be obvious from the preceding remarks that the Paper-manufacturer, for an extended supply of *Material*, must look to a *fibre* or fibrous substance which, either like "Esparto," can be utilized direct, without having to pass through this process of semi-manufacture, or to some other "*New Material*," which, from the peculiarity either of its production or growth, and to the simplicity and economy of its treatment, can be imported into this country, in a condition suitable for his requirements.

Knowing from personal observation the peculiarities of the growth, production, and collection of the "ESPARTO" plant, and believing the time would come when the supply would be unequal to the demand (although I must admit, owing to the rapid extension of the Paper-trade, that time has arrived sooner than I anticipated), I have long and continuously kept my attention directed to any "*New Material*" which appeared likely to become available for Paper-making purposes.

For many years past, I have devoted much time to the investigation of *Fibres*, during which period I have, I believe, tested both chemically and practically as a Paper-maker, nearly every *fibrous material* introduced into the market, with, as may naturally be supposed, extremely variable results.

Before any "*New Material*" will be favourably received by the Paper-manufacturer, it is clear that certain conditions must be fulfilled; these being that such "*Material*" shall favourably compare, so far as regards quality and cost, with those he now employs,

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and that he shall feel satisfied he may rely upon a continuity of supply, not subject to violent fluctuations in price.

Once assured on these points, there can be no doubt that, especially under existing circumstances (viz. deficient supply and high prices), the Paper-trade would gladly welcome the advent of any "*New Material*" calculated to relieve the present, or apprehended scarcity.

NEW MATERIALS.

Fortunately for the Paper-trade, and its supply of materials in the future, two *raw fibrous substances* exist, to which I now desire to direct special attention, as I believe it would be difficult, if not impossible, to meet with any others to compare with them in the essential points, of reliable supply at extremely low cost combined with quality.

With this conviction I have devoted much attention to perfecting a simple and economical system of treating them, in order to produce a fibrous "*Paper-Stock*," considering *that* to be the most practicable and best form in which they can be introduced into the Market.

One of these materials, "MEGASSE," or "BEGASSE," fulfils the main conditions which would be looked for by the Paper-manufacturer, inasmuch as vast quantities are available at a low cost, and owing to the peculiarity of its production being the necessary

by-product of a large and widely spread staple industry —Sugar—not subject to the ordinary irregularity of supply.

"MEGASSE," the fibrous residue of the Sugar-Cane (after it has been crushed to extract the juice), properly prepared, affords a strong, nervous fibre, or "*Fibrous Stock*," which bleaches well, and possesses all the characteristics of a first-class Paper-making material.

"MEGASSE" however, as it comes from the crushing rolls, and even when dried after crushing, is so exceedingly bulky, that (being produced almost exclusively in tropical countries) the cost of carriage added to its great liability to damage from fermentation, precludes the possibility of its being imported to England in its crude state; moreover, the true fibrous portion of "Megasse" does not amount to more than 40 per cent., the remainder being constituted of CELLULOSE, combined with glutenous and other compounds, which of themselves are useless for Paper-making, and which consequently must be separated from the residuary or ultimate fibre.

It follows, therefore, that "MEGASSE" must be converted into a *Fibrous Stock* at, or near, the Sugar factory where it is produced, then dried, and put up in hydraulic-pressed bales for economical transport.

The present value of "MEGASSE" (in its crude condition as produced) is relatively to that of fuel, as, unless it is returned to the soil as manure (which is the practice in some countries), it is employed in the Sugar factories, for raising steam, for motive power, and for evaporating the Cane juice.

As the value of "Megasse" thus considered is very low, factories established in connection with existing sugar mills for the manufacture of "*Paper-Stock*," where sufficient quantities of so bulky a material could be concentrated, and where other favourable conditions exist (of which an abundant supply of water is an essential), would yield a large profit to the planter or sugar manufacturer, as the "*Paper-Stock*" he would produce would meet with a ready sale at prices at least equivalent to "ESPARTO," reduced to the same condition.

Having made "*Paper-Stock*," and "*Paper*" of good quality from "MEGASSE," and determined the profitable result of such a manufacture beyond dispute, I look forward at no very distant date to see the Paper-trade of this country receiving, at least, a portion of its *raw material* from some of our own *Colonies* and *Dependencies* (in most of which Sugar is produced), instead of, as now, being entirely dependent on Foreign Countries for supply.

It is estimated that the consumption of sugar in England amounts annually to upwards of 800,000 tons, or about 57 lb. per head of the population; and as it may be assumed that for each ton of sugar 1 ton of "Megasse" at least is produced, it will be seen that a large reserve of *Fibrous Material* is available, awaiting the enterprise of either the Sugar or the Paper-manufacturer or a combination of both.

It is now my object to show to the *Two parties* mainly interested, the PRODUCER and the CONSUMER, how closely their interests are coincident, and how

both would be benefited by the creation and development of a new INDUSTRY.

The PRODUCER, the Sugar-manufacturer, is, in point of fact suffering from a similar competition to that experienced by the Paper-manufacturer in 1861—handicapped by the *drawback* allowed on the export of FRENCH, AND BELGIAN, BEET-ROOT SUGAR, with which he is unable to compete, in the same manner as the Paper-maker suffered from the introduction of FRENCH, AND BELGIAN, PAPER—*free*, while the RAW MATERIAL —RAGS, paid a heavy *export duty*.

The CONSUMER, the Paper-manufacturer, is suffering from a lack of suitable material, which the Producer is able to supply, and by so supplying and utilizing a by-product, hitherto of little value to him, places himself in a position to meet his competitors on equal, if not better terms in the market.

It is true, that this (to him) new system of utilizing what may now be termed a waste, or by-product, would involve the outlay of additional capital, by the Sugar-planter or manufacturer, which he may deem foreign to his present business, but manufacturers now-a-days make their profits mainly by utilizing by-products.

A familiar instance of this may be cited in the Chemical trade; the muriatic acid produced in the manufacture of soda, formerly run to waste, being now employed for making bleaching powder; and, still more recently, the by-products annaline, anthracene, ammonia, &c., which formerly created a nuisance wherever Gas-Works existed, now constitute a large portion of their profits.

"BAMBOO," the other *Raw Material* to which I have alluded, can hardly be called "*New*," it being well known that both the Chinese and Japanese have from time immemorial employed "Bamboo" for Paper-making purposes; and I have shown in the preceding "Remarks" that attempts have more recently been made, not hitherto affording successful commercial results.

It therefore would have been more correct had I, in directing attention to "BAMBOO," described it as an "*Old material*" under "*New treatment.*" Such indeed was the case with "ESPARTO," an "*Old material*," well known, and tried ineffectually by many, previous to my process for converting it into paper being adopted, which, however, did not take place until it had been fully tested and approved, leading then to its speedy employment.

I believe with my new system of treatment "BAMBOO" will prove to be as superior to "Esparto," in every respect as "Esparto" was found to be superior to "Straw," the only other "*raw material*" used when it was introduced.

"BAMBOO" differs from "MEGASSE," inasmuch as the latter is produced, as it were, involuntarily, its maximum value as a "*raw product*" being determined by its comparison with fuel; whereas "BAMBOO" would have to be cultivated; but, as this plant will not only grow, but flourish, in localities unsuitable for other cultivation, and is produced with such extraordinary rapidity and abundance, it would appear that, as a *Raw Product*, it would not cost much, if any, more than "MEGASSE."

It is hardly my province to discuss here to which of the two materials, "MEGASSE" or "BAMBOO," the preference should be given. Suffice it to say that, with "*the admitted fact*" of the increasing scarcity of *Raw Material* for Paper-making, there is ample scope for both. I have only to add that I shall be happy to advise with parties who may desire to interest themselves in either question.

CONCLUSION.

As I have broadly stated that "*Paper-Stock*" can be produced from both "BAMBOO" and "MEGASSE," to show a good *Profit*, it may be well to mention the present cost of "ESPARTO" reduced to the same condition (of "*Paper-Stock*"), as it is with this *Material* these *Fibres* would mainly have to compete, seeing that with its large consumption and widely extended use for most classes of Paper it now rules the Market.

The cost of good *Spanish* "ESPARTO" at current rates, is, delivered into a Mill (say), 10*l.* per ton; it is generally assumed in the Paper-trade that about 2 tons of "Esparto" are required to make 1 ton paper, the yield being from 48 to 50 per cent.

At 50 per cent. yield therefore we have 20*l.* per ton for "*Raw Material.*" Add to this, for chemicals, boiling, fuel, and labour, 50*s.* × 2 tons, we arrive at 25*l.* for the cost of "Esparto" in the same condition of *unbleached* "*Stock,*" sufficient for 1 ton paper.

"ALFA" or "*African*" Esparto does not afford so

good a yield, neither will it bleach to so high a colour, nor make so good a quality of paper as "*Spanish*"; its value therefore is proportionately lower in the Market, say 8*l.* per ton as compared with 10*l.*: the cost therefore of "Alfa" reduced to a similar condition of "*Stock*" may be taken at 21*l.*

"ALFA" (if carefully selected) so closely resembles "*Spanish*" "ESPARTO," in its *raw condition*, that it is very difficult to distinguish one from the other, and when the two are skilfully blended, it is impossible to do so, until the bleaching process of manufacture is reached; thus, it has happened, that during the past two or three years many thousands of tons of "ALFA," having taken a "tour" through "*Spain*," and being there naturalized, have found their way to England and been sold to the unsophisticated English Paper-maker as "*Spanish*" "ESPARTO," thus supplementing the rapid exhaustion of the indigenous grass of that country.

"WOOD" "*Pulp*," as I have mentioned, is imported, both mechanically and chemically prepared, the latter (unbleached) finding a ready sale, at 24*l.* to 25*l.* per ton; "STRAW" "*Pulp*" also (bleached) realizes 26*l.* to 27*l.* per ton, but neither of these materials are likely to be introduced to any considerable extent.

"*Paper-Stock*," resulting from either "BAMBOO" or "MEGASSE," will show a very large margin of profit from the figures I have quoted, thus allowing for any necessary reduction should prices fall from increased supplies.

In concluding my "*Remarks*," having in the pre-

ceding Pages suggested the conversion of "*Raw Fibrous Substances,*" notably, "BAMBOO" and "MEGASSE," into Fibrous "*Paper-Stock,*" I ought perhaps distinctly to explain the difference between "*Half-Stuff,*" or "*Pulp,*" and "*Paper-Stock,*" and my reasons for expressing a preference for the latter form of preparation,—a preference warranted, I believe, both by practical, and economical considerations.

Whatever "*Material*" the Paper-maker employs, be it Rags (of any denomination) or any other "*Fibre,*" or "*Fibrous*" substance, after Boiling, he disintegrates, or comminutes it into "*Half-Stuff,*" before, or while bleaching. This process, carried a stage farther, converts the "*Half-Stuff*" into "*Pulp.*" Herein, not less than in the proper selection of his "*Raw Material,*" lies the skill of the Paper-maker, as, however good his "*Material*" may be, in its *Raw* or normal condition, it may be very easily spoilt in either of the processes of Boiling,—Bleaching,—or Pulping.

For example, when Bread is once toasted, thereby becoming brown (and the purer and whiter the greater the change), whereby its chemical and mechanical character has become altered, no power can reconvert it into its original condition; in like manner, however good a "*Raw Fibrous Material*" may be, if that "*Material*" be either over-boiled, or over-pulped, no power will restore its normal character.

Moreover, a "*Fibrous*" substance once reduced to the condition of "*Pulp,*" it is difficult, if not impossible, even for a Microscopist, to distinguish accurately

the character or quality of the original "*Fibre*,"—its strength,—or whether it has been properly or improperly treated, and reduced to that condition—until, perhaps too late, when he has bleached it, and converted it, or attempted to convert it, into a sheet of Paper.

With a Fibrous "*Paper-Stock*," however, these objections do not apply, or certainly not to the same degree, as the Paper-maker could readily examine and judge of the character and strength of the "*Fibre*" whether it was clean and free from imperfections or adulterations—in fact, could see what he was buying, or proposing to buy, which he could not do with "*Half-Stuff*" or "*Pulp*."

So far as the Producer is concerned, his outlay for the primary "Plant" and the mechanical appliances, the cost of the subsequent treatment, the drying, packing, and economical carriage and freight from a Foreign country, would in all respects be less for "*Paper-Stock*" than for "*Half-Stuff*" or "*Pulp*."

Speaking from the experience of some years, during which I have conducted the manufacture and sale of many thousand tons of "*Half-Stuff*" prepared from "ESPARTO" and other "*Raw Fibres*," I feel satisfied that in introducing a *New Semi-prepared Material*, from a Foreign country, the preference would be given by the practical Paper-maker to a "*Fibrous Paper-Stock*."

THOMAS ROUTLEDGE.

CLAXHEUGH, SUNDERLAND,
May 1*st*, 1875.

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